Application and Extension of the Automated Atmospheric River Detection Tool in HMT

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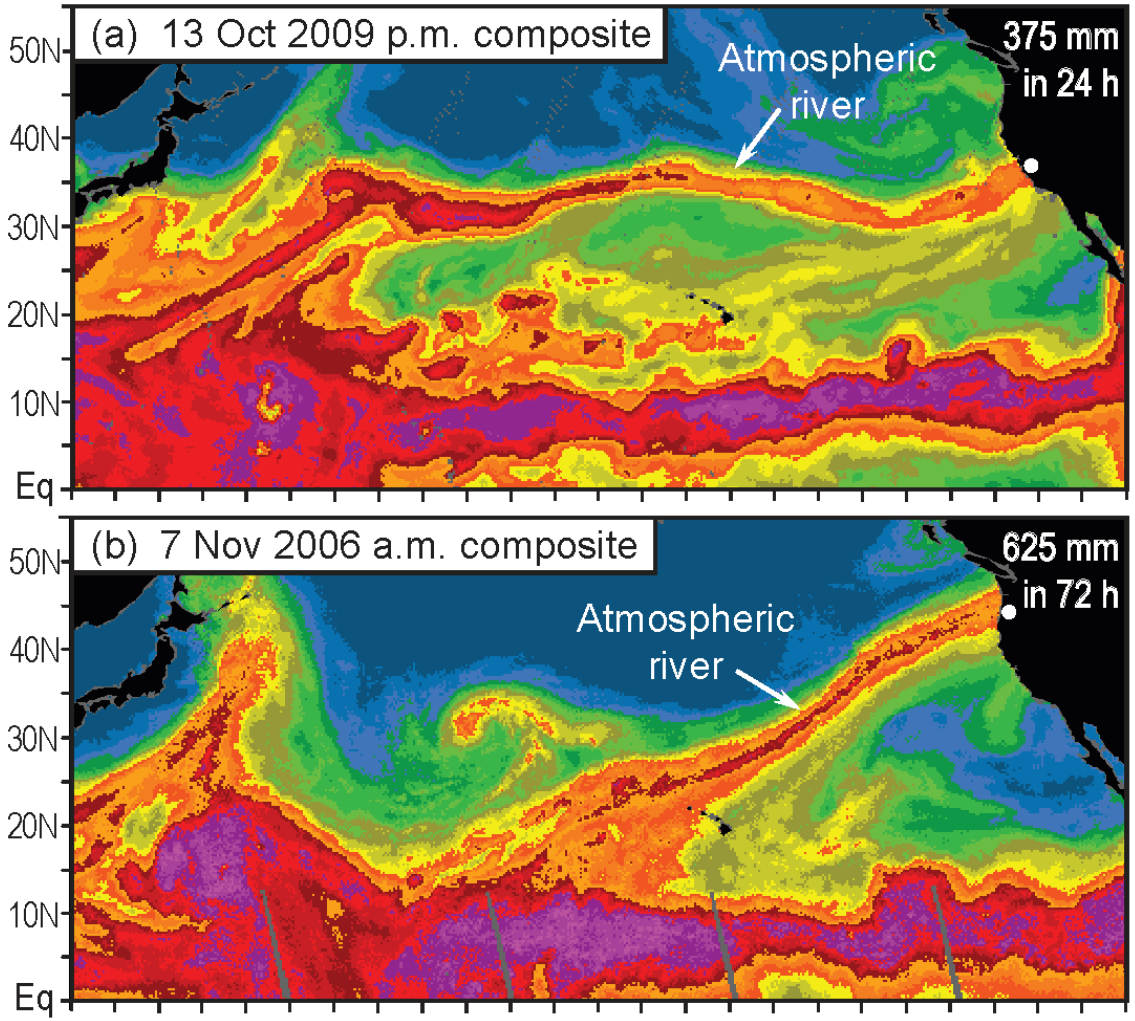
Motivation



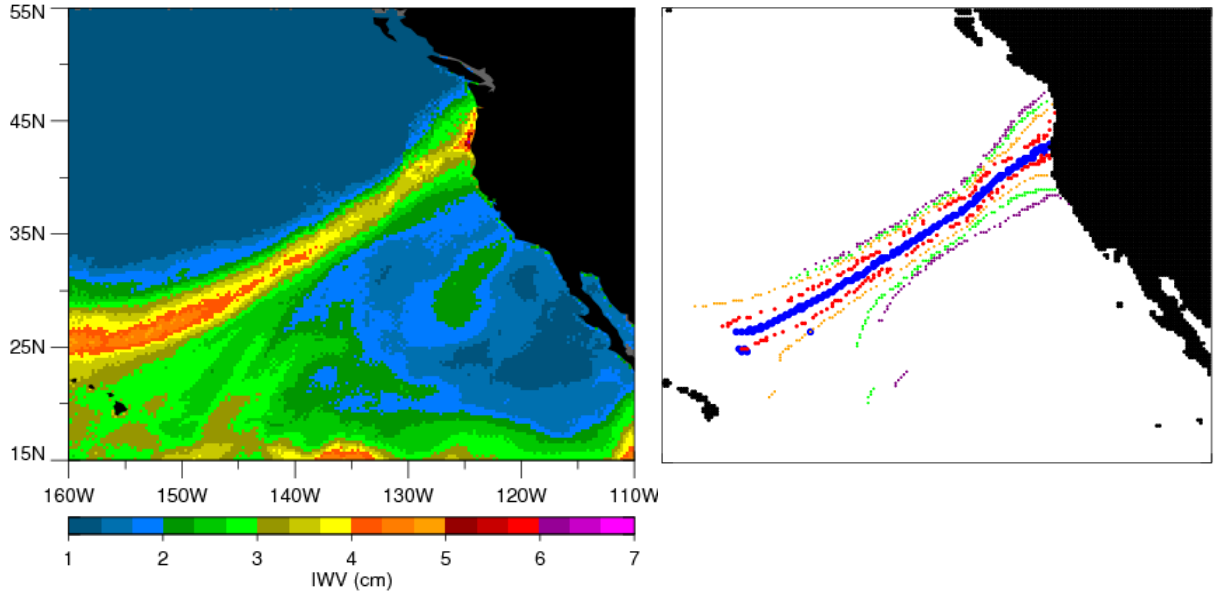
From Ralph et al. 2011, Mon. Wea. Rev.

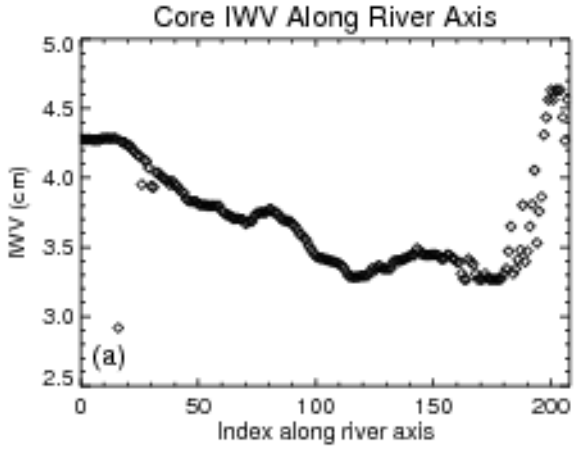
- Atmospheric river (AR) presence linked to extreme precipitation and flooding
  - In upper panel, AR produced 18 inches of rain in 24 hours in central California
  - Below, AR stalled and created 25 inches of rain in 3 days in Pacific NW
- Desirable to have diagnostic indicating severity of threat

Automated AR Detection Tool

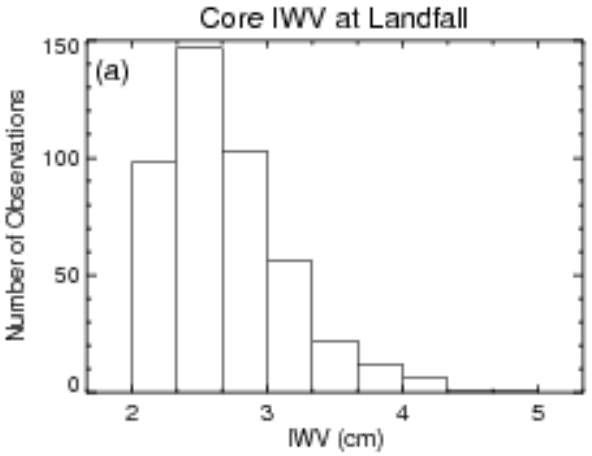
- Automated tool developed for detection of AR events in observed and modeled IWV fields
- Validated against manually identified landfalling events over 5 cool seasons
  - 92.8% critical success index
- Procedure returns core IWV, AR width, and orientation along length of AR
- Recently extended to work with IVT

Sample application on 7 November 2006





Extracted IWV along axis of above AR. Index runs SW-NE.



Extracted IWV near landfall for winter events from 2003-2007

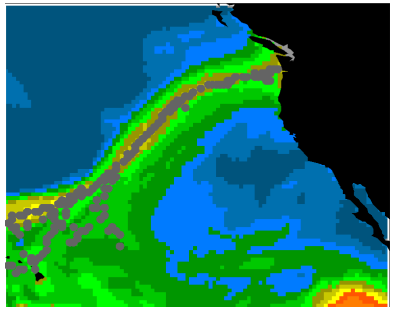
Wick et al., TGRS, 2013

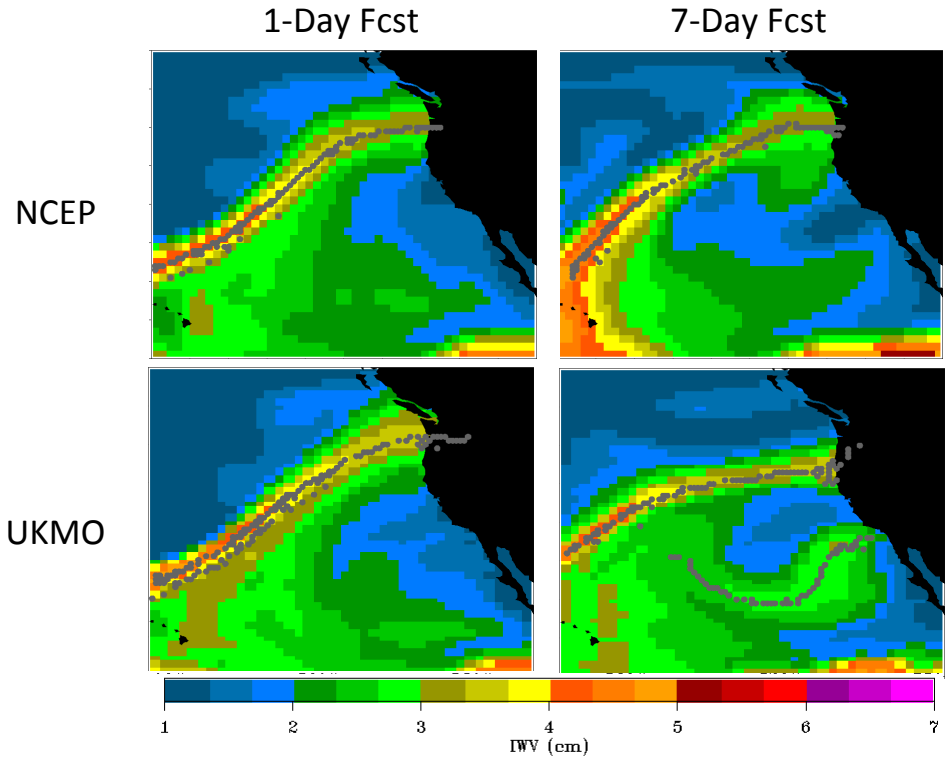
Validation of AR Forecasts - Approach

Automated Atmospheric River Detection Tool (ARDT) applied to evaluate ability of operational NWP models to predict AR events

- AR features in model fields compared with satellite observations from SSMIS
- 5 models tested: NCEP, ECMWF, UKMO, JMA, & CMC
- Evaluated at lead times to 10 days
- 3 cool seasons in NE Pacific from 2008-9 to 2010-11
- Compared frequency of occurrence, width, IWV content, and landfall location

Satellite Observations
January 7, 2009



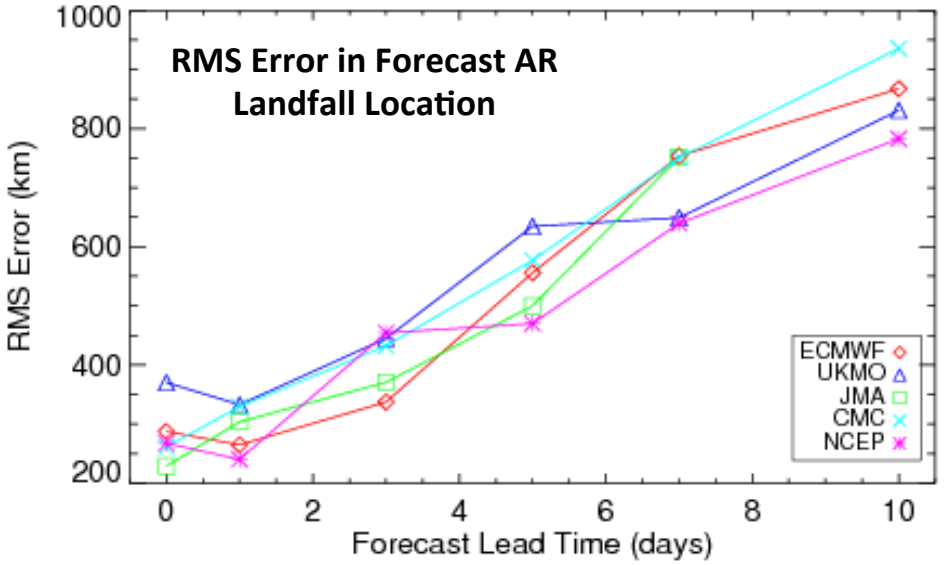


Evaluation of Atmospheric River Forecasts in Operational Ensemble Forecast Systems

G. A. Wick, P. J. Neiman, F. M. Ralph, & T. M. Hamill
NOAA ESRL/PSD, MWR, 2013

Validation of AR Forecasts – Results/Implications

While overall occurrence well forecast out to 10 days, landfall is less well predicted and the location is subject to significant errors, especially at longer leads



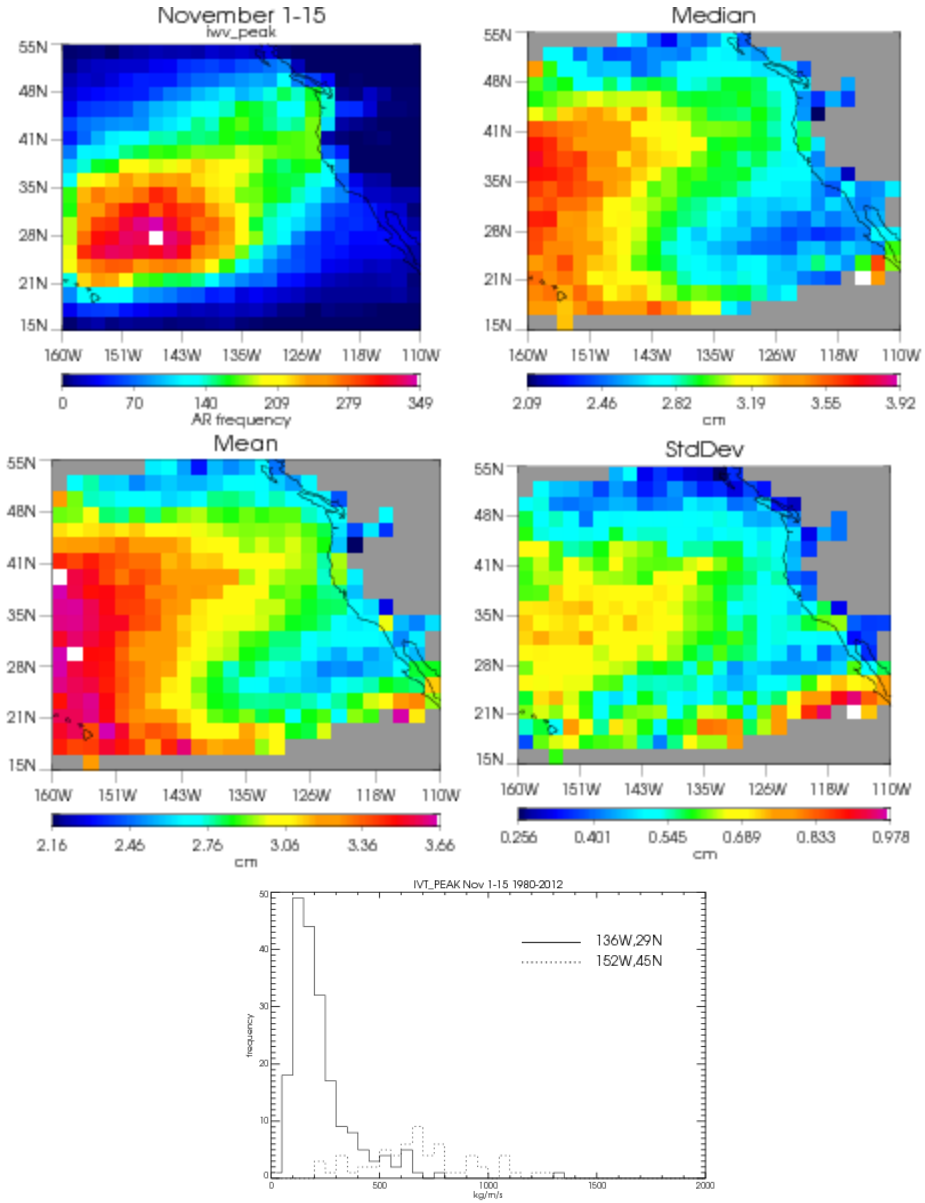
- Errors in location increase to over 800 km at 10-day lead
- Errors in 3-5 day forecasts comparable with current hurricane track errors
- Model resolution a key factor

From Wick et al., 2013

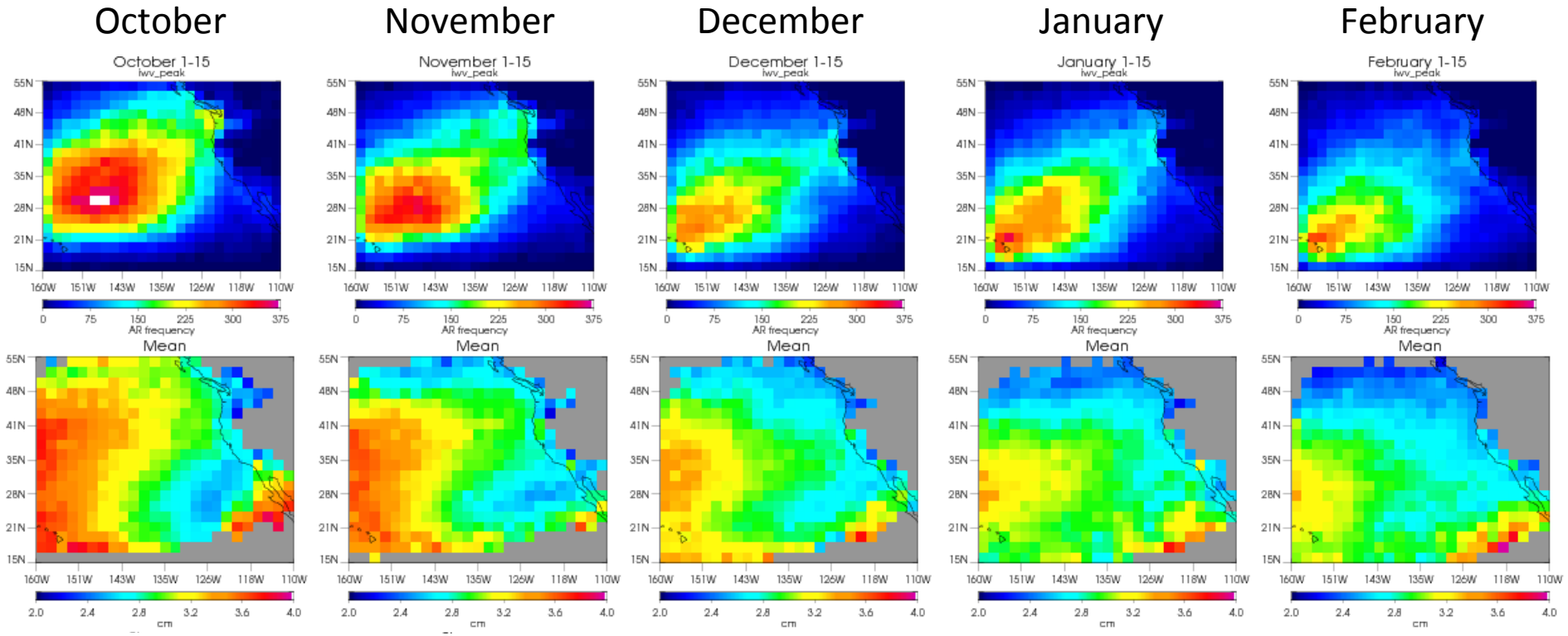
- **Models provide useful heads-up for AR impact and IWV content, but location highly uncertain**
- **Location uncertainty highlights limitations in ability to predict extreme precipitation and flooding**
- **Improvements in predictions clearly desirable**

AR Climatology from CFSR

- Employed Climate Forecast System Reanalysis (CFSR) Data from 1980-2012
- Climatology derived for half-month blocks and 2° grid cells
- AR presence detected in IWV using ARDT
- Statistics accumulated for IWV and IVT when AR present in grid cell
- Real-time events can be compared with climatological statistics
- Ultimate goal to compare with precipitation statistics



IWV AR Climatology Evolution

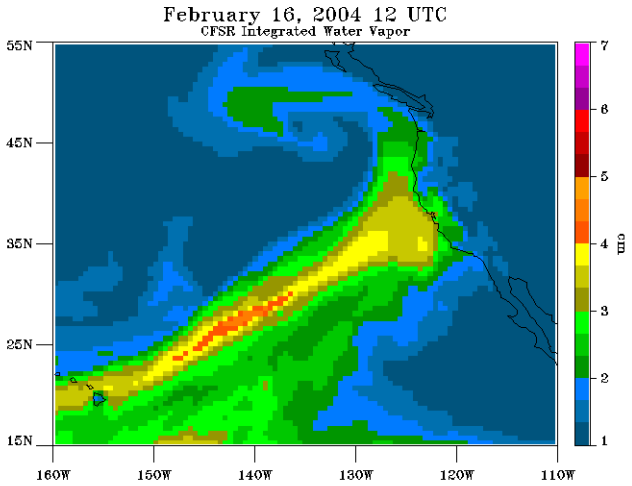


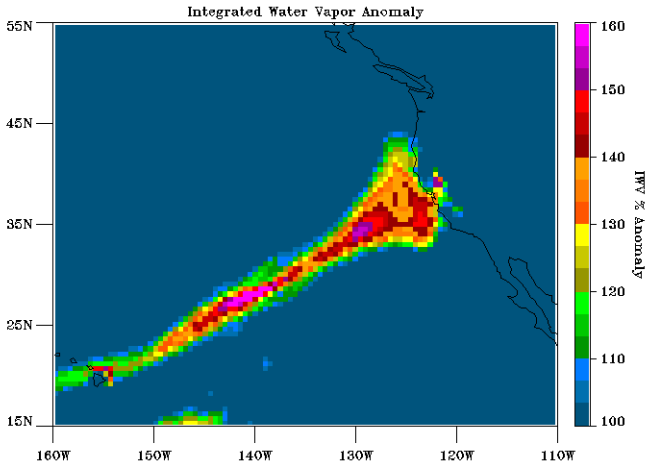
Upper panels: Frequency count of AR detections
Lower panels: Mean of peak IWV content within grid cells

Construction of Severity Indices

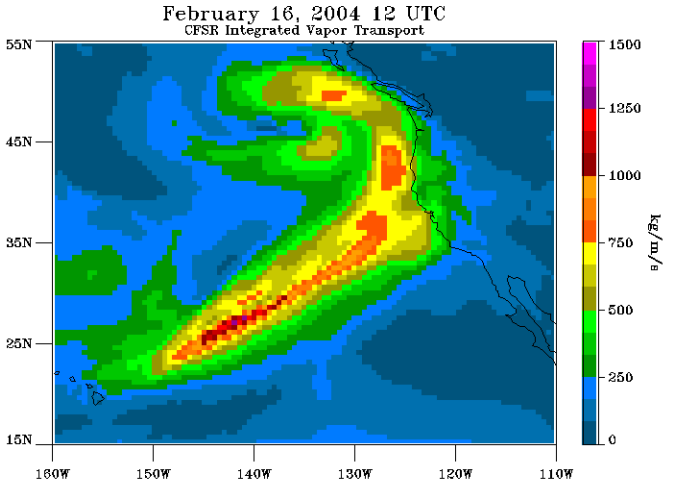
- Individual events compared with climatological distributions
- Ranking computed for IWV and IVT
- Severity displayed by:
  - % anomaly
  - Event percentile

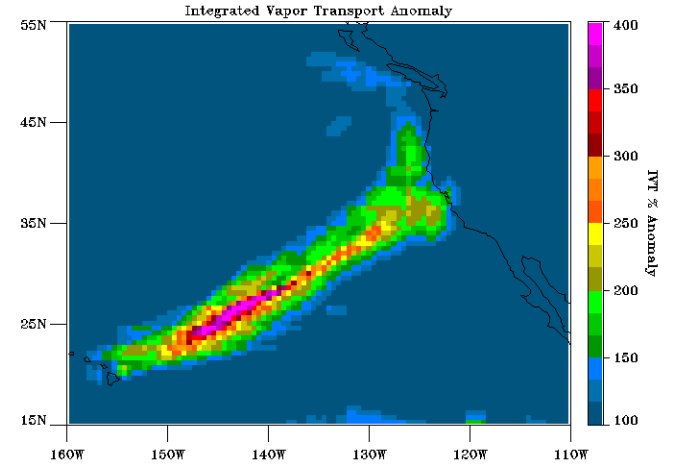
IWV





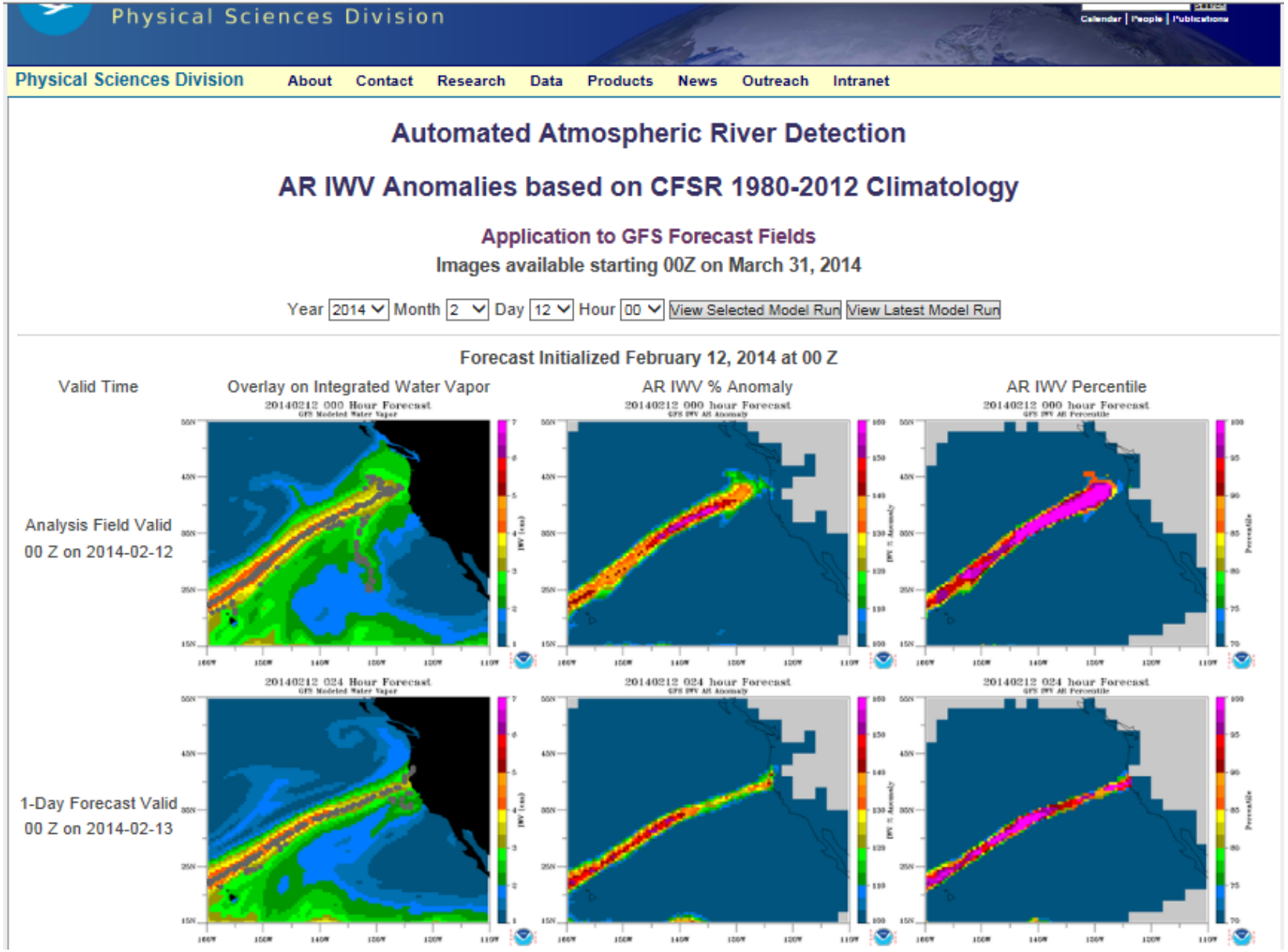
IVT





Real-Time Application

http://www.esrl.noaa.gov/psd/psd2/coastal/satres/data/html/ar_perc_anom_maps.php



Path to Operational Use

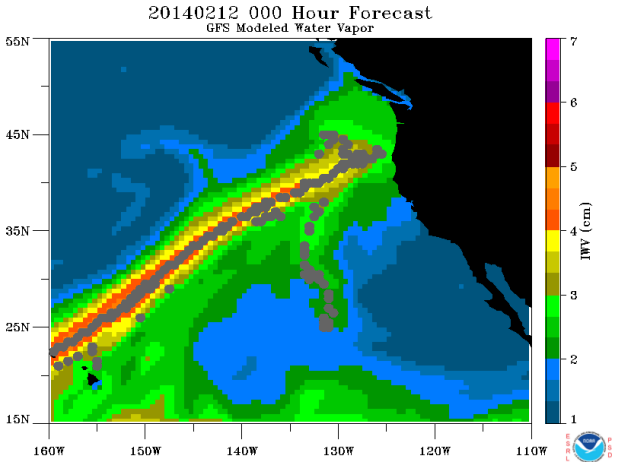
- Working through HMT with Dave Reynolds to solicit forecaster feedback
- IVT signature better correlated to precipitation than IWV
  - Could be source of confusion to forecasters
  - Motivates extension to IVT-based detection
- Exploring relationship to reanalysis rainfall climatology
- Application to additional models

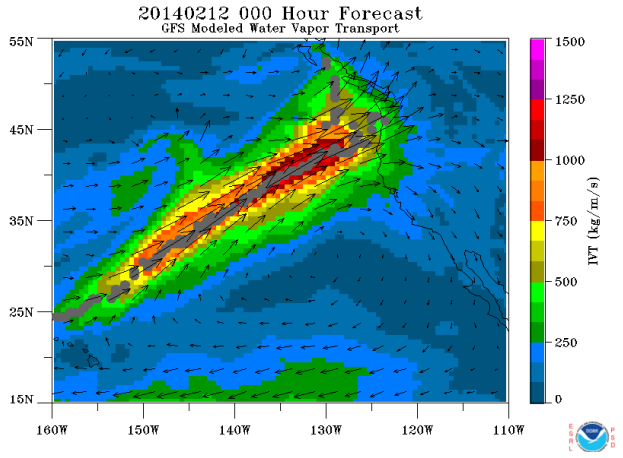
Automated AR Detection Tool for IVT

- ARDT now expanded to function on integrated vapor transport (IVT)
- Threshold based: 250 kg/m/s
- Width and length thresholds relaxed
- Transport required to be aligned with identified AR axis
- Detection more closely tied to features of interest
- Running in real-time at ESRL-PSD

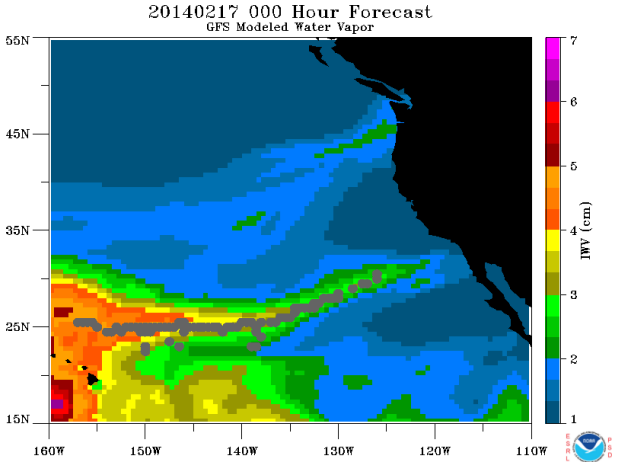
Application to Integrated Water Vapor

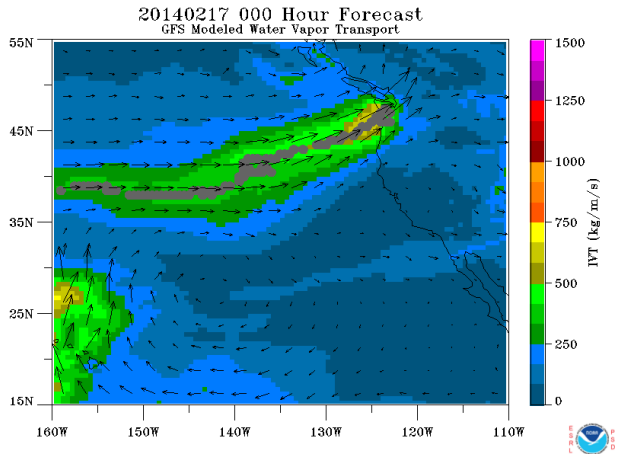
Application to Integrated Vapor Transport





12 February 2014

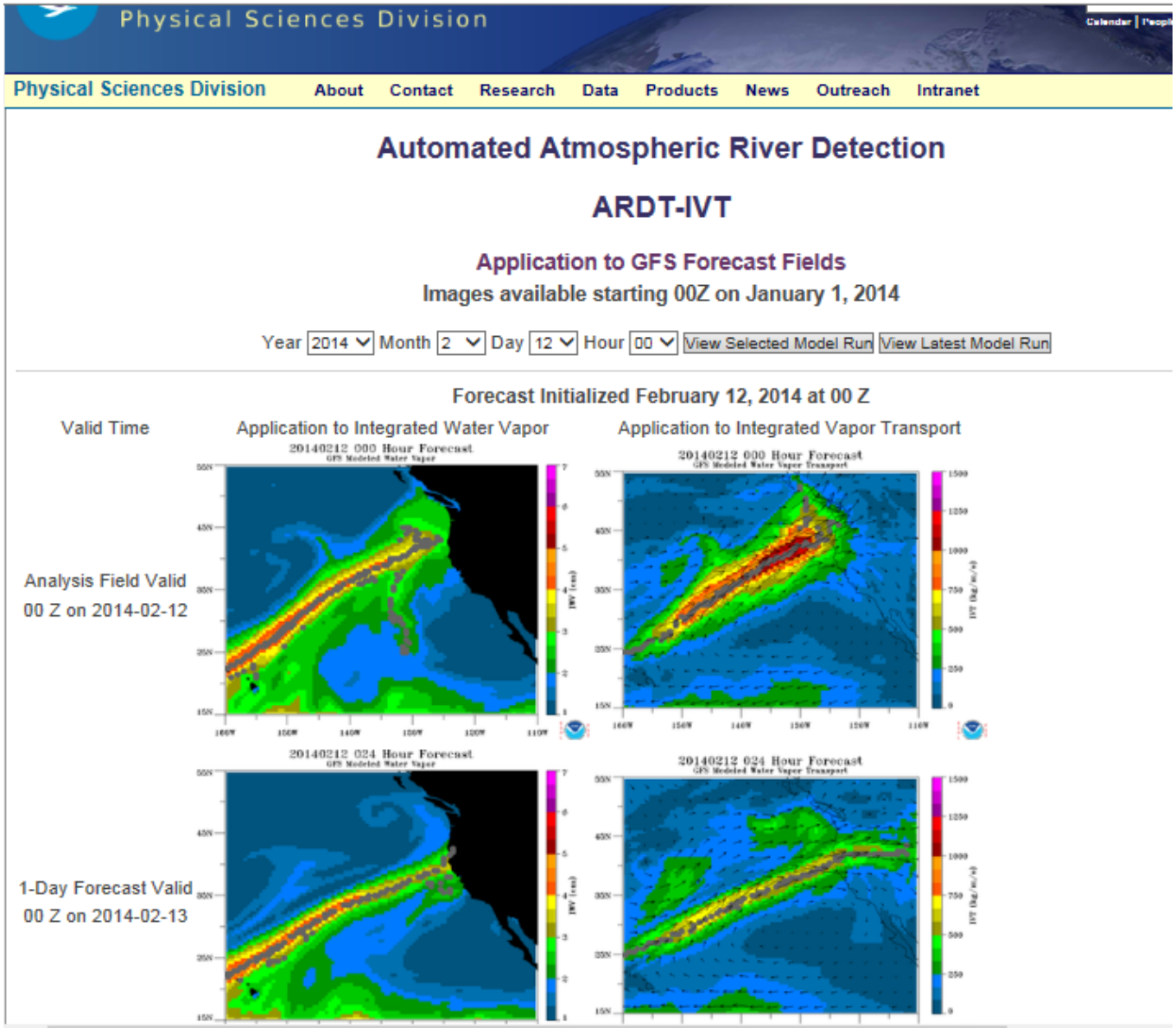




17 February 2014

Real-Time ARDT-IVT Application

http://www.esrl.noaa.gov/psd/psd2/coastal/satres/data/html/ardt_ivt_gfs.php



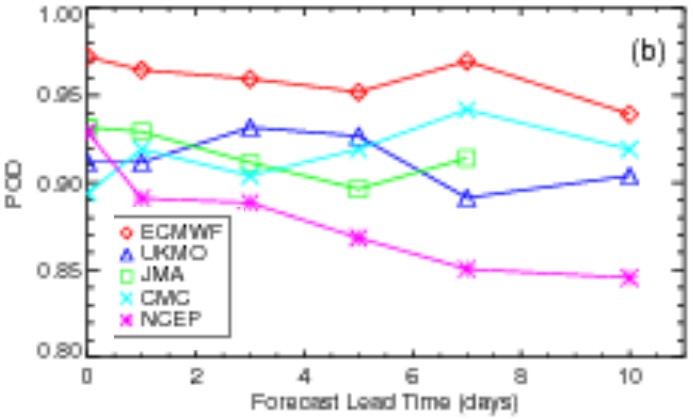
Summary

- Tools exist for automated AR detection in terms of both IWV and IVT
- Technique has provided feedback on numerical models' ability to represent the water vapor signature of ARs
- Used to create 32-year climatology of AR characteristics within CFSR
- Real-time GFS output compared with climatology to generate threat indices for precipitation potential
- Interacting with forecasters now to refine content and optimize utility

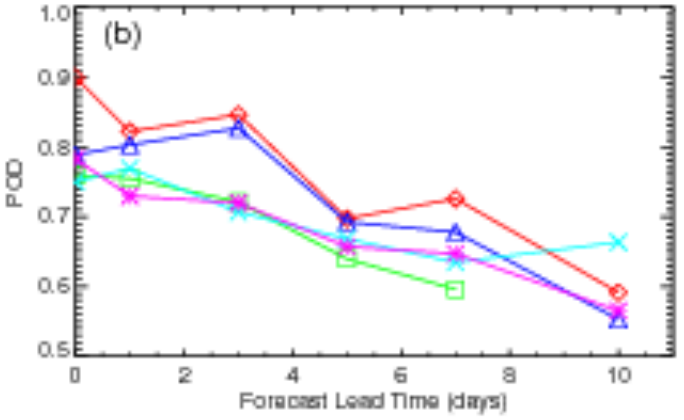
Validation of AR Forecasts - POD

- Probability of Detection (POD) evaluated both for all events and landfalling events
- Overall AR occurrence is very well forecast even at longer lead times
- Landfall occurrence is less well forecast and degrades notably with increasing lead time
- Best results from higher resolution ECMWF model

Overall AR Occurrence



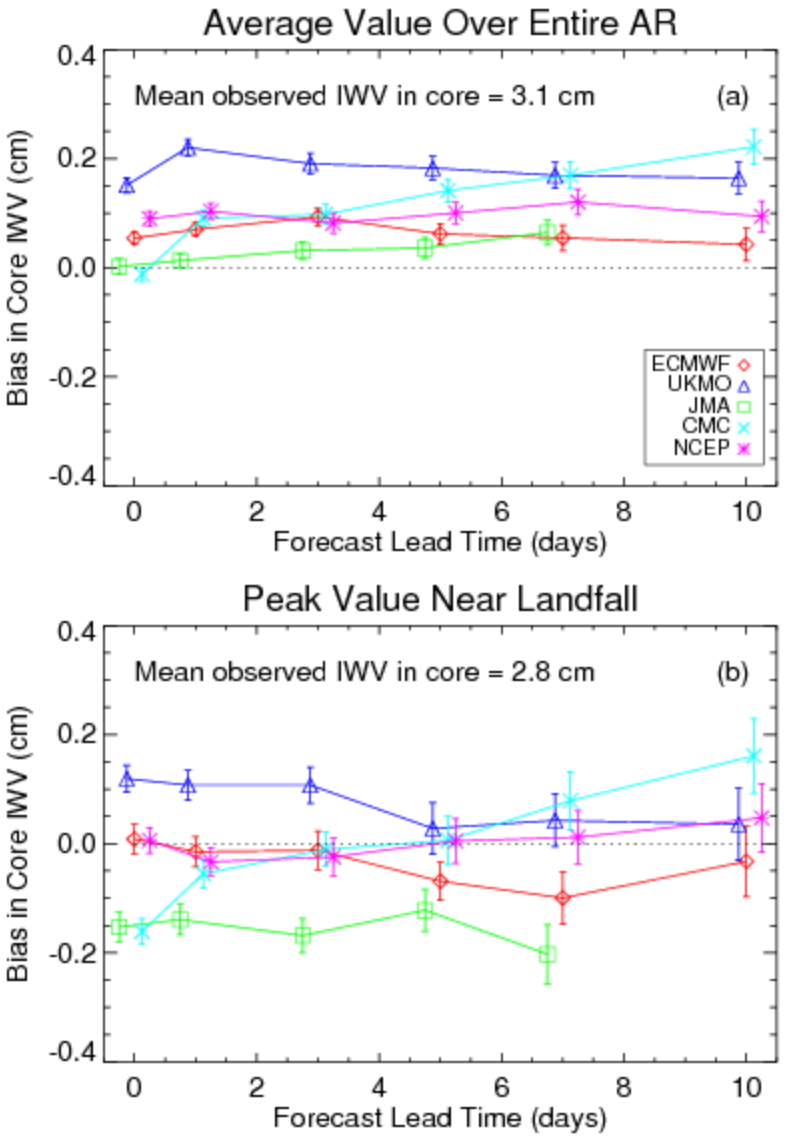
Landfalling AR Occurrence



From Wick et al., 2013

Validation of AR Forecasts – IWV Content

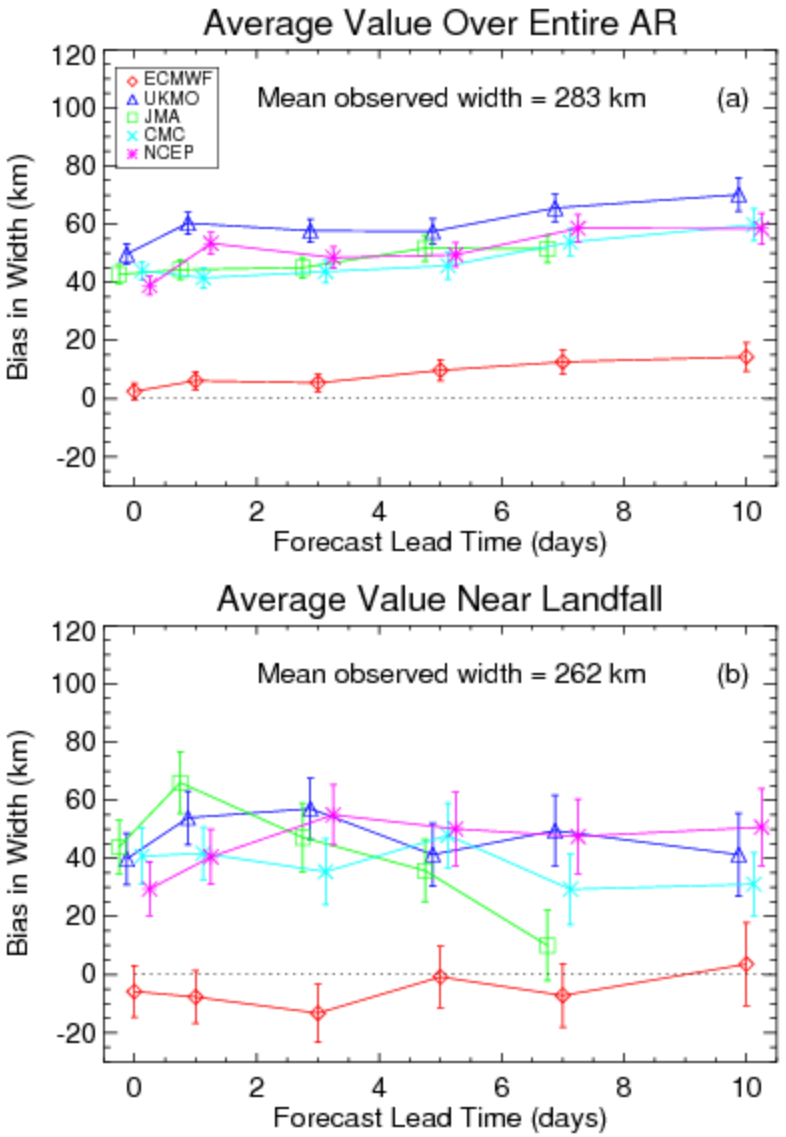
- Integrated water vapor (IWV) content along the detected AR axis compared both over the entire AR length and in the region near landfall
- Overall IWV content is biased slightly moist in model forecasts
- Little IWV bias observed in immediate region offshore of landfall
- IWV bias little dependence on forecast lead time



From Wick et al., 2013

Validation of AR Forecasts – Width

- AR width also compared both over the entire AR length and in the region near landfall
- Coarser resolution models show positive bias in AR width
- Bias over entire AR length increases with forecast lead but changes in width bias near landfall are generally not significant



From Wick et al., 2013